Properties and Uses of Thallium[1]

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History

Although a recent estimate placed the abundance of thallium in the earth's crust in the same order of magnitude as tin, limited commercial production and applications have kept thallium one of the lesser known metals.

It was not until the middle of the last century that thallium was discovered—a fortuity made possible by the use of spectroscopy for qualitative detection of elements. In 1861, W. Crooke resorted to spectroscopic analyses to find tellurium in the residues from a sulfuric acid plant in the Hartz Mountains of Germany and observed an unaccountable green line which he attributed to a new element. He called the element thallium because the color of the line suggested the latin word "thallus" which was used in reference to the bright green tint of new vegetation. Within a year, A. Lamy, working independently of Crooke, noted this same spectral line while also examining residues from a sulfuric acid plant. He succeeded in securing a small quantity with which he established its metallic nature and some of the physical and chemical properties.

For many years the metal had little commercial value, but about 1920 a German company introduced a proprietary rat poison, the active ingredient of which was thallium sulfate. This has remained the most important commercial outlet for thallium.

On the basis of this use, the Fish and Wildlife Service of the Department of the Interior estimated a national requirement of thallium for 1942 of 3,500 pounds and for 1946 of 7,500 pounds. Prior to the war, thallium was imported from Europe—Belgium, France, Germany, and Poland being producers (12). The principal domestic producer is the American Smelting and Refining Company which recovers thallium from cadmium-containing flue dust treated at the Globe Plant in Denver, Colorado; in the past few months the quantity produced has been greatly expanded and for the first time thallium is now available for additional uses.

[1] Paper presented at the Symposium on Rare Metals, Cleveland Meeting, April 19 to 22, 1950.

[2] American Smelting and Refining Company, Research Department, Barber, New Jersey.

Occurrence

Although thallium does not occur in the free state in nature, there are several minerals which contain thallium as a major constituent (16% to 60%)—crookesite, loraridite, hutchinsonite, and urabite, but these cannot be considered commercial ores.

L. H. Ahrens has calculated the abundance of thallium in the earth's crust from its close association with rubidium and concludes that at least 0.0003 per cent must be present (8). This does not include the small amounts found in pyrite ores.

Although the quantity of thallium present in sulfide minerals is small compared to the amount in potash minerals, it is the roasting of these pyrite ores in the production of sulfuric acid and in the smelting operations of lead and zinc that furnishes the chief source of thallium.

Recovery of Thallium

As previously stated, the commercial sources of thallium are the flue dusts of sulfuric acid chambers and lead and zinc smelting and refining operations.

The extracting of thallium from flue dust is largely dependent upon the solubility of thallium and its compounds (oxides and sulfates) in hot water. This was one of the original methods and it is used today with a number of modifications (4, 17, 18).

Thallium metal may be prepared from the compounds by electrolyses of carbonate, sulfate, or perchlorate; by precipitation of metallic thallium with zinc; or by the reduction of thallous oxalate or chloride (1, 16).

A method was suggested by Andrieux in which thallium salts were dissolved in fused boric anhydride, or in alkaline borates, or in fused mixtures of alkali or alkaline earth borates and fluorides, and from these stable baths thallium could be electrolyzed (9).

A smooth coherent deposit of thallium was obtained by Brown and McGlynn with a perchlorate electrolyte using peptone as an anodic depolarizer and cresylic acid as an addition agent (13).

Properties of Thallium

Physical properties.—Thallium is a member of the group IIIB family along with boron, aluminum, gallium, and indium. The element usually has a bluish-grey tinge, but a freshly cut surface will have a metallic luster which dulls rapidly on exposure to air. It is somewhat softer than lead and harder than indium; the ratio is approximately $H_{Pb}:H_{Tl}:H_{In}4:2:1$. The metal has high malleability and low tenacity.

The crystal structure of α Tl is hexagonal close-packed (lattice constants are $a = 3.450$, $c = 5.514$, Kx-units). A transformation takes place above 230°C and β Tl is formed which has a body-centered cubic lattice ($a = 3.874$) (30, 31).

Thallium is a superconductor at temperatures in the region of liquid helium similar to its close neighbors Pb and Hg. Below 2.32°K all measurable resistance disappears (24, 49, 22).

Measuring the change of volume in metals during solidification, Endo found a 3.23 per cent change in volume for thallium during solidification (27).

The cubic compressibility as determined by Richards and White at 20°C over a pressure range of 100–500 megabars is 2.83×10^{-6} for thallium as compared to 2.40×10^{-6} for lead (32).

As may be seen in Table I, thallium resembles lead in a number of physical properties (3).

The vapor pressure of thallium is given by Coleman and Egerton between 845–900°K as $\log p \text{ mm} = \frac{-8927}{T} + 7.993$ (25).

Nuclear fission has been observed in thallium by using deuterons, He ions, and neutrons. Artificial radioactive isotopes of thallium have been produced by deuteron and neutron bombardment (33, 34, 35).

Chemical Properties.—Thallium oxidizes slowly in air at 20°C and more rapidly as the temperature is increased. In water containing air, thallium is oxidized to thallium hydroxide, but in oxygen-free water it does not react at ordinary temperatures (20).

Thallium forms two distinct groups of compounds: thallous with a valence of one and thallic with a valence of three. The thallous salts are the most numerous and stable. Some water-soluble thallous compounds are the acetate, nitrite, nitrate, perchlorate, hydroxide, carbonate, sulfate, and ferricyanide. The sulfide and chromate are insoluble and the halogens are only moderately soluble in hot water. Hydrogen sulfide will pre-

cipitate Tl_2S from acetic acid, alkaline, or neutral solutions but not from solutions containing mineral acids.

The best solvent for thallium is HNO_3 which forms thallous nitrate. Dilute H_2SO_4 will dissolve the metal slowly forming Tl_2SO_4, but with concentrated acid the solution is readily effected. Thallium is only very slowly dissolved by HCl.

Zinc, aluminum, or magnesium will precipitate metallic thallium from solution (5).

Uses of Compounds

The most important uses for thallium are in the form of compounds. The sale of thallium salts, particularly thallium sulfate for the destruction of rodents and ants, is by far its greatest commercial outlet (61, 62, 53, 63).

Although the sulfate is the most widely used of the thallium poisons, other stable water-soluble salts such as carbonate and acetate are used (62). The thallium poison is usually applied to wheat or bread in the form of a paste generally made from starch, sugar, glycerine, and water. The advantage of thallium sulfate over many rodenticides is that it is odorless and tasteless, giving no warning to the cautious rats.

The medicinal uses of thallium compounds are very limited and require care in use since the margin between toxicity and therapeutic benefits is narrow. In the treatment of ringworms it is used to produce alopecia (62).

Thallium oxisulfide ("thallofide cell") is employed in a photosensitive cell and is particularly sensitive to low intensity and long wavelengths in the infrared range. The use of this cell for signaling in the dark has been proposed (60, 54, 55).

Mixed thallium bromide-iodide crystals were synthesized in Germany for use in military infrared optical instruments. Superior chemical and mechanical stability and increased range of infrared transmission has made these crystals appear promising for infrared applications (56).

The General Electric Company has developed a Tl_2S cell for use as a semiconductor device which depends upon the change of electrical resistance with the amount of radiation falling on it. The greater the amount of radiation the lower the resistance of the Tl_2S film (57).

The oldest ultraviolet phosphors are thallium-activated alkali halides. (Ultraviolet phosphors are materials emitting fluorescent radiation of predominantly shorter wavelength than visible light.) An investigation of phosphors capable of converting primary ultraviolet radiation in the erythemal (suntan) range reveals that several types of alkaline earth silicates and phosphates activated with thallium not only showed a good initial erythemal emission but maintained a high per cent of this emission for several hundred hours (65, 67). A patent exists on an ultraviolet fluorescing material (U.S. Pat. 2,417,038, Sylvania Electric Products Inc.) containing KCl 25–50 per cent, Tl_2SO_4 3 per cent, balance $Ca_3(PO_4)_2$ (65). KCl and NaCl crystals activated by TlCl are capable of ultraviolet phosphorescence (64, 66).

Other minor uses of thallium salts are as "getter" in tungsten lamps, in glass when a high refractive index is required, and as an antiknock constituent of motor fuel (15, 52).

Binary Alloys (6, 7)

The binary systems of thallium have been widely investigated and practically all the systems of the major metallic elements have been determined, i.e., Li, Na, K, Cu, Ag, Au, Mg, Ca, Zn, Cd, Hg, La, Al, In, Sn, Pb, As, Bi, Se, Te, Mn, Ni, and Pt.

Thallium alloys readily with most of these elements; the exceptions are Cu, Al, Zn, As, Mn, Ni, and Se which have a limited solubility in the liquid state. The systems of thallium with Cu, Al, Zn, and Ni resemble the lead system in that they have very low liquid and solid solubility.

The alkali and alkaline earth elements form a series of compounds with thallium and, in general, these compounds readily oxidize in air. The Ca-Tl and Mg-Tl are characterized by the high solid solubility of thallium in calcium and magnesium.

The element lanthanum forms unusually high melting compounds, e.g., La_2Tl (melting point 1260°C), LaTl (melting point 1182°C), and $LaTl_3$ (melting point 1096°C).

Silver, gold, cadmium, and tin form simple eutectiferous systems with the following eutectic points:

Ag-Tl—289°C—98.7% Tl
Au-Tl—131°C—73% Tl

TABLE I

	Thallium	Lead
Atomic No.	81	82
Atomic weight	204.39	207.21
Density—20°C g/cm³	11.85	11.34
Density—20°C lb/in.³	0.4281	0.4097
Atomic volume—cm³/g atom	17.24	18.27
Melting point	303°C	327.4°C
Boiling point	1460°C	1740°C
Specific heat—20°C/cal/g/°C	0.031	0.031
Heat of fusion—cal/g	7.2	6.3
Coefficient of linear thermal expansion—micro in./°C	28.0	29.3
Thermal conductivity—cal/cm²/cm/°C/sec	0.093	0.083
Electrical resistivity—microhm/cm	18 (0°C)	20.65 (0°C)

TABLE II

System	Composition	Eutectic
Pb-Sn-Tl	—	no ternary*
Sn-Cd-Tl	19 Cd, 42 Sn, 39 Tl	129.5°C
Bi-Pb-Tl	55.2 Bi, 33.3 Pb, 11.5 Tl	90.8°C
	42.2 Bi, 9.8 Pb, 48.0 Tl	186.4°C
Bi-Sn-Tl	50 Bi, 35.7 Sn, 14.3 Tl	124°C
	44 Bi, 31.0 Sn, 2.5 Tl	167.6°C
Bi-Cd-Tl	43 Bi, 40.8 Cd. 16.2 Tl	124°C
	38.2 Bi, 36.4 Cd, 25.4 Tl	146.6°C
Cd-Pb-Tl	—	no ternary†
Pb-Sn-Bi-Tl	46.5 Bi, 28 Pb, 14 Sn, 11.5 Tl	93°C
Pb-Cd-Bi-Tl	44.3 Bi, 11 Cd, 35.8 Pb, 8.9 Tl	81°C
Bi-Cd-Sn-Tl	49.1 Bi, 18.2 Cd, 23.4 Sn, 9.2 Tl	94.6°C

* A quasi-binary eutectic exists between $PbTl_2$ and Sn at 181.8°C but no ternary eutectic occurs (26).

† In the ternary system of Pb-Cd-Tl, an invarient point exists at 210°C which is not a eutectic (41).

Cd-Tl—203°C—83% Tl
Sn-Tl—170°C—43.5% Tl

Antimony and bismuth form intermetallic compounds with thallium. The lowest eutectic in the Sb-Tl system is 195°C at 80 per cent Tl and the lowest eutectic in Bi-Tl system is 188°C at 52.5 per cent Tl.

High mutual solid solubility exists between thallium and indium, and thallium and lead. The indium system has a continuous solid solubility interrupted only by a two-phase field between 55 and 80 per cent Tl. Lead has a similar solid solubility but surprisingly the alloys of Pb-Tl melt at temperatures higher than either element.

An intermetallic compound is formed between mercury and thallium which melts at 145°C. This compound divides the system into two eutectic systems, both having low temperature eutectics:

Tl— Hg_3Tl_2 0.6°C—40.50% Tl
Hg—Hg_3Tl_2 −60°C — 8.5% Tl
(Hg−38.9°C melting point)

Ternary Systems

Jänecke has presented a number of ternary and quaternary diagrams involving the elements Pb, Bi, Cd, Sn, and Tl (26). Table II gives the eutectic points found.

No quinary eutectic was formed by adding thallium to a Pb-Sn-Bi-Cd alloy, although the melting point was reduced to 67° C by the addition of 6 per cent Tl (26). Köster and Wagner, and Köster and Kam, investigated the magnesium corners of the Mg-Tl-Cd, Mg-Tl-Al, Mg-Tl-Zn, and Mg-Tl-Ag (36, 37, 38, 39).

Uses of Alloys

Although a majority of the binary and several ternary systems have been investigated, there are, at present, no commercially important alloys.

Several outstanding properties of thallium alloys have suggested possible uses. For instance, the Pb-Tl alloys (20% or more) are relatively insoluble in many strong acids. This property suggests the use of Pb-Tl alloys as insoluble anodes in the electrowinning of metals (43). An alloy suitable for coating metal pipelines, well-castings, etc., has been patented recently. The alloy contains 10 Tl, 20 Sn, 5 Sb, 3 Cu, and balance Pb, and is said to be highly resistant to corrosion. Alloyed with silver, 10-20 per cent Tl produces an alloy highly resistant to HCl, H_2S, and atmospheric corrosion (46).

The addition of lead to thallium raises the melting point above that of the components and for this reason these alloys have found limited use in special types of fuses (15).

Since the addition of 8.5 per cent thallium to mercury lowers the melting point from −39°C to −60°C, this amalgam is often used in low-temperature thermometers and in other applications where a liquid metal is required at low temperatures.

Thallium alloys of lead, tin, or indium as well as thallium itself are superconductors at temperatures below that of liquid air (49).

When thallium (6%) is added to Lipowitz metal the eutectic temperature is lowered from 70°C to 66.6°C. The addition of thallium to the low-melting (46.5°C) alloy of Lipowitz metal plus indium does not lower the melting point (28).

Ellis claimed that the addition of thallium to Pb-base alloys markedly improves their resistance to deformation. Yield-point and ultimate-strength tests are said to show that an alloy containing 72 Pb, 15 Sb, 5 Sn, and 8 Tl is superior to the best SN-base bearing alloy (42).

Hensel found that a silver-thallium bearing alloy had good antifriction properties and extremely low rates of corrosion as compared with silver-lead and copper-lead. He has patented several bearing alloys containing thallium with lead and copper and also thallium with gold and silver. The claim is that the presence of thallium results in a fine dispersion of the soft phase (lead or thallium). Hensel also has patents on electrical contacts of gold and silver with amounts of thallium from 0.05 to 5 per cent. The thallium is supposed to form a finely divided phase which decreases the tendency of the contacts to stick (44, 45).

Patents on magnesium alloys containing thallium have been granted. For example, an alloy of 3–12 per cent Tl, 0.1–0.3 per cent Ce, balance Mg is said to have good formability associated with high tensile and yield strengths (47, 48).

Conclusions

The properties and uses of thallium and some of its compounds have been described briefly, and although a surprising amount of information is available on some aspects of this metal, there is little known about the properties of most of the alloys, and in many instances, even about the more common compounds. Now that this element is more readily available, new uses and applications will probably be developed.

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Current Affairs

Buffalo Meeting, October 11, 12, 13, and 14

From all indications, the 98th Meeting of the Society, to be held in Buffalo, New York, will fulfill members' expectations. Organization of the local committee has been completed and the details of the program have been arranged for another meeting in keeping with the Niagara Frontier tradition.

Following the meeting of the Board of Directors on Wednesday afternoon, the general meeting will begin with a cocktail hour preceding an informal dinner and evening of entertainment—both active and passive.

Technical sessions will start Wednesday morning, and will run through Saturday. A large number of papers have already been received for the symposia planned on Batteries, Corrosion, Electrodeposition, and Electro-Organic Chemistry. In addition, a full-day round table on electric furnace operation will prove of interest to many members.

Plant Trips

Plant inspection trips are scheduled for both Thursday and Friday afternoons. Included will be the Westinghouse Electric Corporation motor assembly plant (Thursday), E. I. du Pont de Nemours viscose plants producing rayon, cellophane, and sponge (Thursday and Friday), Huntley Station steam electric generating plant (Friday), Buffalo Electrochemical Company installation of the contact rectifier (Friday), and Colonial Radio Corporation electronic equipment plant (Friday).

Luncheons and Dinners

The Thursday luncheon will be dedicated to the memory or our late past-president, Raymond R. Ridgway.

The luncheon hour on Friday is open for group luncheons, which may be arranged directly with the hotel management by chairmen or secretaries (elected or self-appointed) of the groups. Correspondence should be addressed to Mr. J. R. Hewett, Sales Manager, Hotel Statler, Buffalo, New York.

On Thursday evening there will be a reception, followed by a dinner at which the Acheson medal and prize will be presented. A concert by the Guido Chorus will round out the evening.

For the many guests who will want to see Niagara Falls without cutting other parts of the program, there will be an informal reception at Niagara Falls Friday evening. This will afford an opportunity to see the Falls both by daylight and by artificial illumination, in small groups with personal (nonprofessional) guides.

Ladies' Program

The ladies' program will start with a reception and tea at the headquarters hotel Wednesday afternoon. On Thurs-

Fitzgerald Air Photo

AIR VIEW OF BUFFALO BUSINESS DISTRICT AND PASSENGER DOCKS

MARVIN J. UDY
General Chairman

day there will be an all-day trip down the Canadian side of the Niagara river, with a visit to old Fort George, near the mouth of the river, and a stop for lunch at the General Brock Hotel in Niagara Falls, Ontario. (Aliens should carry passports for re-entry into the United States.) A party at the Buffalo Country Club is being planned for Friday afternoon.

Local Committee

The committees in charge of local arrangements are as follows:

General and Advisory Committee
Marvin J. Udy, General Chairman; A. T. Hinckley, Ralph B. Hammond

Arrangements Committee
Raymond G. Brown, Chairman; Eugene J. Nutting, Keith Demmon

Registration Committee
Neal J. Johnson, Chairman; Milton Janes, Allen G. Gray

Entertainment Committee
R. B. MacMullin, Chairman; C. N. Richardson, C. A. Stiegman

Plant Visits
W. C. Gardiner, Chairman; George J. Easter, J. W. Caster, W. M. Fotheringham

Finance Committee
J. C. Pernert, Chairman; A. H. Ballard, Myron C. Cory, R. L. Murray, H. C. Parkman, B. E. Field, C. H. Chappell.

Publicity Committee
Matthew Weber, Jr., Chairman; A. E. Jennings, J. S. Newberry, Jack Shore

Ladies' Program Committee
Mrs. R. R. Ridgway, Chairman; Mrs. James King, Mrs. W. C. Gardiner, Mrs. Axel Heilborn, Mrs. J. C. Pernert, Mrs. R. B. MacMullin, Mrs. M. J. Udy

* * *

Buffalo is easily accessable by rail, air, road, or lake steamer, and commands ready access to the whole Niagara Frontier on both sides of the river.

Along this natural boundary, once heavily fortified, the ancient structures of Fort Erie, Fort Niagara, Fort George, and Fort Mississauga have been reconstructed as mementos of past conflicts and monuments to present friendship.

The museum of the Buffalo Historical Society contains many exhibits illustrating the political and natural history of the region, as well as a renowned collection of Chinese vases, some of which date back as far as 3000 years. The Albright Art Gallery has a large collection of sculpture and of modern French paintings. The Kleinhans Music Hall is one of the world's finest examples of acoustical construction.

Whether you are interested in these cultural attractions or in the natural beauties of the Niagara river, with its

A. T. HINCKLEY
Chairman, Advisory Committee

falls and gorge, bordered with parks, you will find stimulation in this region. And whether you spend your summer on the torrid plains or in the humid lowlands, you will find the thought of Buffalo in October cheering and cooling. There, at the leeward end of Lake Erie, the October air carries a tang that will whet your appetite and add to your enjoyment of the various phenomena associated with high concentrations of electrochemists.

Future Meetings of The Electrochemical Society

Buffalo, October 11-14, 1950

Washington, April 8-11, 1951

Detroit, Fall, 1951

Philadelphia, Spring, 1952

Montreal, Fall, 1952

Local Section Advisory Committee

The Local Section Advisory Committee has been formed in an effort to aid the Local Sections of the Society in planning their programs and in the general conduct of their affairs. The chairman of the committee is ex officio a member of the Board of Directors of the Society, and thus for the first time Local Sections have a representative on the Board. The chairman at present is former president W. C. Moore.

One of the principal means by which the committee can aid the Local Sections is by acting as a clearing house for speakers and in helping to plan tours of speakers to the various sections. If any members reading this notice believe they have something of interest to present to the various sections in the way of a lecture on electrochemical topics, or can suggest a good speaker, it would be appreciated if they will get in touch with the secretary of the committee, Dr. F. A. Lowenheim, Metal & Thermit Corporation, P. O. Box 471, Rahway, New Jersey.

Suggestions and criticisms dealing with the handling of Local Section affairs are always welcome.

SECTION NEWS

Detroit Section

The Detroit Section met on April 21st at Wayne University in Detroit. At this meeting, the following officers were elected for 1950-51:

Chairman—C. O. Durbin, Engineering Division, Chrysler Corporation

1st Vice-Chairman—W. P. Innes, General Motors Research Laboratories

2nd Vice-Chairman—M. L. Baty, Engineering Division, Chrysler Corporation

Secretary-Treasurer—A. W. Linn, Research Laboratories, United Chromium, Inc.

Mr. D. Trivich of Wayne University was elected as representative to the Local Section Advisory Committee for a two-year term. Elected in 1949, Mr. L. M. Morse, Engineering Division of the Chrysler Corporation, is the other representative to this committee.

Guest speaker at this meeting was Mr. Joseph F. Conway, Jr., of the Magnavox Company. Choosing "Television" as his topic, Mr. Conway covered both the technical and popular aspects of the subject. He discussed tube construction and projection systems and, in particular, the development of the cathode-image tube. In addition, the technical aspects of transmission and reception, as well as the synchronization of receivers, were covered. Mr. Conway concluded his interesting talk with a summary of the work that has been done in the

development of color television, and a discussion of "Strato-Vision," a system for providing television for rural areas.

Mr. Myron W. Turner of The Electric Storage Battery Company was the featured speaker at the May 19th meeting of the Detroit Section, held at Wayne University. Mr. Turner's subject was "Industrial Storage Batteries and their Application."

In his talk, Mr. Turner discussed the construction of industrial batteries in relation to the service required. For many applications, the tubular type of construction is the most economical, particularly when the battery will be completely discharged before recharging. The pasted plate type of construction is used for automotive batteries.

According to Mr. Turner, the chief aims of battery research in recent years have been toward increasing battery life and reducing the size and weight of the batteries. The speaker then pointed out the many uses of batteries. They are employed extensively in power control in backing up telephone exchanges, railroad signal systems, and public utilities. Some states require storage battery protection of all public meeting places. Seventy-five to one-hundred thousand batteries are used as the motive power for trucks used within plants. Such trucks have the advantage over gasoline-powered trucks in the elimination of fumes and fire hazard. Batteries are also used for powering mining locomotives.

Mr. Turner's talk was enjoyed by all who attended this last meeting of the Section's 1949–50 season.

M. L. Baty, *Vice-Chairman*

Midland Section

The Midland Section held its fifth meeting of the 1949–50 season on May 18th in the Dow Auditorium at Midland. Dr. Robert Gesell of the Physiology Laboratory of the University of Michigan was the featured speaker. His topic was "Electrochemical Aspects of Neurophysiology."

Dr. Gesell, in this interesting talk, described the physical structure of the central nervous system, the generation of electricity by nerve tissue, and the role of electrical currents in the transmission of nerve impulses. Various theories bearing on the origin and implementation of the electrical potentials produced by the nervous structure were presented and discussed.

Sizable differences in potential (100–150 mv) are observed between the inside and outside of nerve cells, the polarity being such as to cause current to flow from the inside to the outside of the nerve sheath. These potentials are attributed to the higher metabolic rate of nerve tissue and to the semipermeable nature of the nerve sheath. While the role of electric currents in the propagation of nerve signals is not well understood, it is believed that the major nerve terminals, even in a state of rest, generate a continuous circulatory current, thereby maintaining themselves in a continuous state of readiness. When stimulated, the nerve dendrites feeding the nerve terminal augment the "steady state" current to the point where the nerve cell "fires" and an impulse is transmitted along the nerve "circuit." The speed of these impulses, approximately 100 meters per second, suggests an electrochemical rather than a purely electrical transmission mechanism.

Studies made with timed, electrical stimulation of nerve centers show that the amplitude of the muscular response to nerve impulses is controlled by the frequency of the stimulation. The regulatory mechanism in this case is believed to involve the generation of acetyl choline by the nerve tissue and its subsequent destruction by an enzymatic reaction.

Dr. Gesell's talk was well received and provoked a lively discussion.

H. A. Robinson, *Secretary-Treasurer*

Pittsburgh Section

A joint meeting of the Pittsburgh sections of The Electrochemical Society and the American Electroplaters' Society was held on May 13th. The speaker of the evening was Dr. N. Thon of Princeton University who described the work being done under his direction on the "Porosity of Electrodeposited Coatings." An interesting discussion followed.

The next meeting of the Pittsburgh Section was held on June 16th at the Alcoma Country Club. Four technical papers were presented in a morning and an afternoon session, with a luncheon at noon. The speakers and their subjects were:

Dr. Marie A. Fischer, School of Medicine, University of Pittsburgh, "The Use of the Electrophoresis Apparatus in Studies of Plasma Proteins"

Dr. Robert D. Williams, Aluminum Company of America, Research Laboratory, "The Polarograph as a Research Tool in the Study of Corrosion Processes"

Dr. D. S. McKinney, Carnegie Institute of Technology, "Thermodynamics and Mechanisms of Corrosion Reactions"

Dr. R. T. Koenig, Gulf Research & Development Company, "Bimetallic Corrosion in Neutral Electrolytes"

At the conclusion of the technical program, the members and guests enjoyed the facilities of the club.

J. M. Bialosky, *Chairman*

San Francisco Section

The last meeting of the San Francisco Section for the 1949–50 season was held May 17th at the St. Julien Restaurant in San Francisco.

The officers elected for the coming year are as follows:

Chairman—Edward B. Sanigar, Naval Radiation Defense Laboratory, Naval Shipyards, San Francisco, Calif.

Vice-Chairman—Charles G. Maier, Consulting Engineer, Los Altos, Calif.

Secretary-Treasurer—Richard F. Bechtold, Great Western Division, The Dow Chemical Company, Pittsburg, Calif.

The guest speaker for the evening was the outgoing Chairman, Mr. Howard B. Richman, Superintendent of the Cell & Brine Department, The Dow Chemical Company, Pittsburg, California. The subject was "Electrolytic Chlorine Cells."

Mr. Richman began his talk, which was well illustrated by slides, with a discussion of the chemistry involved in the operation of these cells. The principal side reactions which occur and their cause and effect were described. A flow sheet of a typical electrolytic chlorine alkali plant using diaphragm-type cells was presented and discussed from the standpoint of equipment, material, and operation.

The speaker then turned to a description for several cells of both major types, i.e., diaphragm and mercury cells. An interesting note is that, during the last twenty years or so, the mercury-type cell was developed to a much higher degree than the diaphragm-type cell in Germany, while during the same period the opposite was true in this country. Since the end of World War II, however, considerable interest in mercury cells has been apparent in the United States.

The trend in diaphragm cell development in this country has been always to increase the capacity and yet to maintain approximately the same outside physical dimensions. This has been accomplished by devising means of increasing the effective anode area without increasing cell size. Various operating characteristics and economic factors have also been greatly improved during the years.

Concerning mercury cells, Mr. Richman devoted most of his discussion to the Hoechst horizontal cell. The original mercury cells used a rocking motion to circulate the mercury and amalgam between the electrolyzer and decomposer compartments. Later designs used a pump. The Germans continued the development of the latter design and operated cells of very high capacity. Their latest development was a vertical type cell which had extremely high capacities and yet was of relatively small physical size.

The talk was enjoyed by all who attended. A lively question and answer discussion followed.

R. F. Bechtold, *Secretary-Treasurer*

MEMBERS:

.... A Convention Cruise?

Members who enjoy Electrochemical Society meetings will be interested to learn that, in response to many requests, tentative plans are being made to combine the Fall 1952 Convention in Montreal with a cruise on the famous Saguenay River. As an added attraction to the technical sessions and entertainment aboard ship, there will be stopovers at unusual points of interest along the way, including a day at Arvida, center of the largest electrochemical operation in the world.

Preliminary figures from the Canada Steamship Lines set the cost for the complete trip, including all meals, at $65.00, which is little more than you pay for hotel and meals when attending a meeting in any large city. The boat will leave Montreal at 7 P.M. EST, Wednesday, September 24, 1952, and return to Montreal at 6 A.M. Sunday, September 28.

Your help is needed before the cruise can be scheduled. Arrangements must be made in the near future to reserve a ship for the exclusive use of the Society, but before final commitments are made, we must have assurance from the members that the meeting will be well attended.

The Board of Directors has requested that those who plan to take the trip make a deposit of $25.00 so that an estimate may be made of the number who will attend. It will be necessary to have 300 reservations by December 1, 1950. If there is insufficient response, the trip will not be scheduled and the deposit will be returned.

If you would like to take this cruise, please send your deposit *promptly*, together with any suggestions you may have, to the Secretary of the Society, Dr. Henry B. Linford. The address is 235 West 102nd Street, New York 25, N. Y.

Thanks for helping us plan this 102nd Convention!

BOOK REVIEWS

PRINCIPLES OF ELECTROPLATING AND ELECTROFORMING by William Blum and George B. Hogaboom. Published by McGraw-Hill Book Co., Inc., New York, 1949. 436 pages, $6.00.

This up-to-date revision of an old and well-recognized text and reference on the subject of electroplating and electroforming is much welcomed by those interested in teaching and applying electroplating.

The revised third edition is truly a complete revision in that the whole physical arrangement of the material has been altered. The authors have devoted the first two-thirds to three-fourths of the book to the general principles underlying the science of electroplating, tests on finished products, analysis of plating solutions, preparation of the basis material, and description of various types of equipment to be used.

The various plating baths have been classified according to the periodic table. In other words, copper, silver, and gold are considered in one chapter.

It is our opinion that this book will undoubtedly regain the stature that it had in the field of electroplating in the period just after the last revision had been made.

HENRY B. LINFORD

PHENOMENA, ATOMS, AND MOLECULES by Irving Langmuir. Published by Philosophical Library, New York, 1950. 400 pages plus Bibliography and Index, $10.00.

A more accurate title would be "Some Collected Papers," in view of the fact that about twenty of Irving Langmuir's previously published researches of the past thirty-five years are collected in this volume. New material includes an introduction by Dr. Langmuir, a bibliography of all his publications, and an index. An unfortunate omission occurs in not listing with each paper the corresponding literature reference which would have enabled the reader to more adequately appraise the papers in light of the period and times in which they were written. Most of the collected papers were written several years before World War II. The reader will find, nevertheless, a wealth of unexplored ideas relevant in principle or detail to the very frontiers of present-day classical science.

The subjects range from science in modern society to surface chemistry, atomic hydrogen, discharge through gases, electron emission and chemical valence. The logic, approach, and techniques described by the author will serve to guide and inspire generations of scientists to come. This fact, perhaps,

(*Continued on page 176C*)

PERSONALS

GERALD A. ROBBINS has accepted a position as manager of the Denver City, Texas, plant of the Frontier Chemical Company, Midland, Texas. The company's chief products are caustic soda and muriatic acid. Mr. Robbins was formerly associated with Julius Hyman & Company of Denver, Colorado.

W. C. GARDINER, of the Mathieson Chemical Corporation in Niagara Falls, New York, has been appointed to the editorial staff of the JOURNAL as a Divisional Editor. In his new capacity, Dr. Gardiner represents the Industrial Electrolytic Division of the Society.

R. H. TILLMAN, associated for many years with the Consolidated Gas, Electric Light & Power Company of Baltimore, has retired and is living in Riderwood, Maryland. Mr. Tillman was recently made an emeritus member of the Society.

BERNARD AGRUSS is now Head of the Battery Department in the Brooklyn Research Laboratories of the National Lead Company. Dr. Agruss was formerly a research engineer at the Engineering Research Institute of the University of Michigan, Ann Arbor, performing research and development work on lead acid storage batteries.

CHARLES F. POGACAR, who has been with the Mellon Institute of Industrial Research, is now associated with the Koppers Company in Pittsburgh, Pennsylvania.

Dunning New Dean of Engineering at Columbia

Dr. John Ray Dunning has been appointed dean of the School of Engineering at Columbia University, New York City, succeeding Dean James K. Finch.

Dr. Dunning, professor of physics, scientific director of Columbia's great new cyclotron at Irvington-on-Hudson, New York, and a pioneer in atomic research, is well known as a scientist and administrator. He is especially qualified for his new position in that his many activities have included both the fields of pure science and engineering.

Dean Finch, an outstanding figure in Columbia's long history of engineering education, has been a member of the Engineering School staff since 1911. He became dean in 1946 after serving as acting dean during most of World War II. Following his retirement, Dean Finch will continue to teach, resuming the chair of Renwick Professor of Civil Engineering, which he formerly held.

NEW MEMBERS

In June, 1950, the Board of Directors elected the following to membership in The Electrochemical Society:

Active Members

OWEN G. BENNETT, The Catalyst Research Corporation, mailing add: 6101 Falls Road, Baltimore 9, Maryland (Battery)

RICHARD J. BRUEHLMAN, Brush Beryllium Company, mailing add: 25850 Tungsten Road, Euclid 17, Ohio (Electrothermic and Theoretical Electrochemistry)

WILLIAM H. COLNER, Armour Research Foundation, mailing add: 9562 Calhoun Avenue, Chicago 17, Illinois (Corrosion, Electrodeposition, and Theoretical Electrochemistry)

ROBERT K. CUMMINS, General Electric Company, Quartz Section #45, 1133 E. 152nd St., Cleveland 10, Ohio (Electrothermic)

RINALDO M. CURCIO, Permo, Inc., mailing add: 4151 W. Arthington Street, Chicago 24, Illinois (Electrothermic)

BIANCHI GIUSEPPE, Laboratorio di Elettrochimica del Politecnico, Piazza Leonardo da Vinci, 32, Milano, Italy (Electrodeposition and Theoretical Electrochemistry)

POLI GUIDO, Laboratorio di Elettro-

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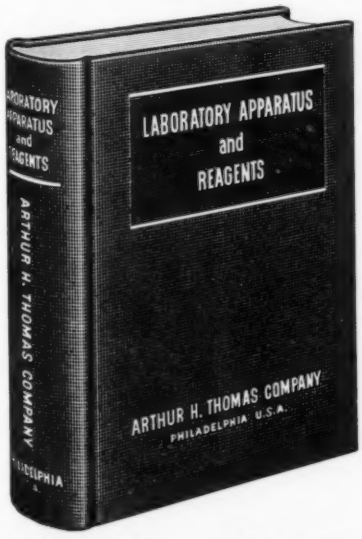

Facsimile of Catalogue, size 8¼ x 10½ x 2½ inches.

The new 1472-page edition of our general catalogue LABORATORY APPARATUS AND REAGENTS illustrates and describes over 15,000 Apparatus items, together with 6,000 Reagent items, all selected primarily for use in laboratories of Chemistry and Biology. The many new items include a comprehensive assortment for use in Microchemistry.

In addition to a code word adjacent to each item—for economical ordering by teletype, telegraph or cable—the new edition includes net and shipping weights for convenience in estimating shipping charges, with particular reference to air service.

When requesting copies of this catalogue, scientists will greatly oblige us by a full statement as to their professional connection with organized laboratory work, and purchasing officers by information as to final disposition of the catalogue, i.e. in the purchasing office or in the laboratory.

We welcome suggestions from those in authority as to the number of catalogues required for convenient use in any laboratory, department, institution or establishment. Such cooperation aids us in making adequate distribution without unnecessary duplication.

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chimica del Politecnico, Piazza Leonardo da Vinci, 32, Milano, Italy (Theoretical Electrochemistry)

ADOLPH GUNZENHAUSER, Transisola, Inc., mailing add: 617 West End Avenue, New York 24, N. Y. (Electric Insulation)

RALPH F. HOECKELMAN, Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio (Electrodeposition, Electrothermic, and Industrial Electrolytic)

MARTIN H. JOHNSON, JR., Ray-O-Vac Company, mailing add: 415 N. Johnson St., Stoughton, Wisconsin (Battery)

EDWARD ORBAN, Monsanto Chemical Company, mailing add: 556 Kling Drive, Dayton 9, Ohio (Theoretical Electrochemistry)

DOMINIC T. PALUMBO, Sylvania Electric Products Inc., mailing add: 1652 64th St., Brooklyn 4, New York (Electrothermic)

JEROME S. PRENER, General Electric Research Laboratory, Schenectady, New York (Electronics)

WILLIAM T. RAWLES, General Electric Co., mailing add: 21 Revilla Terrace, Pittsfield, Massachusetts (Electrothermic)

MANUEL SHAW, Chrysler Corporation, Eng. Div., 12800 Oakland Avenue, Highland Park 3, Michigan (Corrosion, Electric Insulation, Electronics, Electro-Organic, and Theoretical Electrochemistry)

MERLE E. SIBERT, Horizons Incorporated, 2891 East 79th Street, Cleveland 4, Ohio (Electrodeposition)

ROGER G. SWEET, The Catalyst Research Corporation, mailing add: 8533 Willow Oak Road, Towson 4, Md. (Battery)

JOHN M. TINNON, Air Reduction Co., 60 E. 42nd Street, New York, N. Y. (Electrothermic)

ROLAND WARD, University of Connecticut, Storrs, Connecticut (Corrosion, Electronics, and Theoretical Electrochemistry)

LAWRENCE T. WEAGLE, Radio Corp. of America, Harrison, New Jersey (Electronics)

JOHN P. WOOLLEY, The Catalyst Research Corporation, mailing add: Ruxton 4, Md. (Battery)

Reinstatement

HENRY S. NEWHALL, Pittsburgh Lectromelt Furnace Corp., mailing add: Herron Lane, Glenshaw, Pennsylvania (Electrothermic)

Book Review

(*Continued from page 174C*)

is the main justification for assembling in one volume these reports of past research.

The collected papers are only one-tenth of the number which Langmuir so far has published as a member of the General Electric Research Laboratory. They constitute an outstanding monument to the author, and also to the Laboratory which sponsored his researches and allowed their publication. They are also a significant monument to Willis R. Whitney who first established and directed the G. E. Laboratory, and who convinced the management that research in pure science would "pay off." It was he who enthusiastically formulated, then maintained, and later vigorously defended the "academic freedom" which was so acceptable to Langmuir, who came to the laboratory as a young college instructor, and also to his colleagues, many of whom were likewise destined to fame in the scientific world. Without the atmosphere created by Whitney, which remains unique even today, research in pure science would not have been done at Schenectady and this volume of collected papers might have taken a different form. Science and technology benefited greatly through the coincidence of events that brought Langmuir and Whitney together.

H. H. UHLIG

RECENT PATENTS

Selected for electrochemists by Fred. W. Dodson, Chairman of the Patent Committee, from the Official Gazette.

March 14, 1950

Haendler, H. M., and Burger, L. L., Application 631,420, Method for Analyzing Fluorocarbon Compositions

Ellis, G. B., 2,500,169, Battery Filler Device Having a Puncturing Element for Piercing an Evacuated Battery Enclosing Can

Schaefer, R. A., 2,500,205, Method of Plating

Schaefer, R. A., Mohler, J. B., and Pochapsky, H., 2,500,206, Apparatus for Plating

Wells, W. H., Stephens, W. E. Shoupp, W. E., and Haxby, R. O., 2,500,223, Artificial Atomic Disintegration

Heyrovsky, J., 2,500,284, Apparatus for Electroanalysis

Richardson, E. L., 2,500,572, Electrostatic Precipitator

Gibson, R. C., and Russell, W. S., 2,500,673, Process of Producing a Phosphate Coating on Metals High in Aluminum

Sieling, D. H., 2,500,878, Cataphoretic Apparatus

March 21, 1950

Rieger, E. W., and Klein, C. J., Application 614,254, Electroplating

Friedman, H., 2,500,941, Geiger-Mueller Counter Structure

Kent, D. W., 2,500,949, Top for Electrolytic Cells of the Tank Type

Herzog, G., 2,501,174, Radioactive Measuring

Nagel, F. J., and Horstman, C. C., 2,501,349, Insulation for Magnetic Material

Hedberg, C. W. J., 2,501,513, Electrical Precipitator

Colbert, W. H., Weinrich, A. R., and Morgan, W. L., 2,501,563, Method of Forming Strongly Adherent Metallic Compound Films by Glow Discharge

Eltenton, G. C., and Fallgatter, M. B., 2,501,599, Photoelectric Colorimeter

Robinson, P., 2,501,616, Soldering Iron Tip

March 28, 1950

Rothrock, G. M., Application 630,140, Manufacture of Ethylbenzene Derivatives

Glassner, A., 2,501,673, Powdered Zinc Anode for Primary Cells

Ives, C. Q., 2,501,676, Method of Testing Insulating Walls

Varian, R. H., 2,501,702, Vacuum Gauge

Ogle, C. R., and Freeman, P. B., 2,501,785, Electric Current Rectifying Couple and Process of Forming Same

van Geel, W. C., and Dekker, A.J., 2,501,798, Blocking-Layer Cell

Gifford, C. E., 2,501,846, Production of Silicon Steel Sheet Stock having the Property of High Surface Resistivity

Rust, F. F., Vaughan, W. E., and Wheatcroft, R. W., 2,501,966, Halogenation of Peroxides

Greeff, M., 2,502,399, Thermoelectric Generator

April 4, 1950

Koller, L. R., Application 717,393 Electrostatic Precipitator

Dodd, S. R., and Ayres, R. F., 2,502,441, Phosphate Coating of Metals

Mehltretter, C. L., and Dvonch, W., 2,502,472, Electrolytic Preparation of Calcium D-Arabonate

Waterman, H., 2,502,495, Apparatus for Copper Plating

van Amstel, J. J. A. P., 2,502,540, Method of Manufacturing Blocking-Layer Cells of the Selenium Type

Albrand, W., 2,502,692, Regulation of Two Stage Automatic Charging of Storage Batteries

Harriss, L. H., 2,502,723, Deferred-Action Dry Battery.

Ravenscroft, A. W., 2,502,888, Electrolytic Cell

Tichenor, R. L., 2,503,179, Battery Charging Method

Prust, A. F., 2,503,217, Process for Treating Brightened Electrotinplate

EMPLOYMENT SITUATION

Position Wanted

ELECTROCHEMIST, M. Sc., experienced mainly in batteries and allied fields with responsible positions in research development, product engineering, production engineering, sales engineering, and administration. Publications and patents. Desires position of responsibility in development manufacturing or sales engineering. Available one month notice. *Reply to Box 341.*